bodies, and not with one. That was very important; but you will see from the photograph, that it is very unlike the spectrum of nebulæ, so that it required a certain amount of faith when the spectrum was observed to be such as you see it here, to suppose that after a certain time, when the action which produced the greater luminosity was reduced and the light toned down, we should eventually get the spectrum of a nebula.

Well, as a matter of fact, the Nova reappeared in August 1892, and was observed to have increased in brightness from the 16th magnitude in April to about 9th magnitude. What, then, was the spectrum? It had almost completely changed; and among the first to observe the new spectrum was Prof. Campbell, of the Lick Observatory. This observer then stated that "the spectrum resembles that of the planetary nebulæ." In the following month the spectrum was also observed by Drs. Copeland and Lohse, and their observations seemed to them to "prove beyond doubt that Nova Aurigæ is now mainly shining as a luminous gas nebula." The most striking evidence on this point, however, is that afforded by the photographic investigations of Von Gothard. He not only shows us the photographic spectrum of the new star at this stage of its history, but gives us also the spectra of several nebulæ to compare with it; and it is evident that we were certainly dealing, in the case of the Nova, with the same spectrum as in the nebulæ. Dr. Gothard, at least, was satisfied on this point, and stated that "the physical and chemical state of the new star resembles at present (September and October 1892) that of the planetary nebulæ."

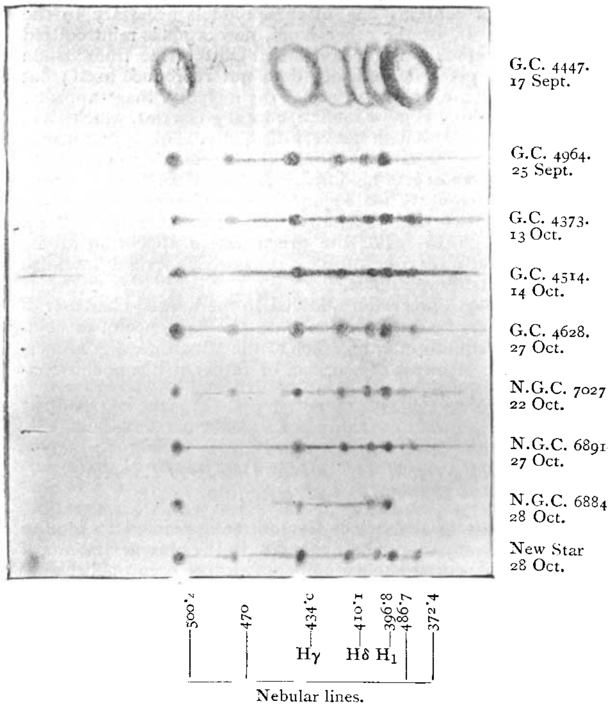

Fig. 37.—The spectrum of the new star in Auriga, as compared with the spectra of planetary nebulæ (Gothard).

So you see we get, first of all, the hard fact that the spectrum indicated the existence of two bodies; and then the very much harder fact for some, that, after the war was over, we got back to the condition of the nebulæ. I need not tell you that there is not universal agreement on this point, and chief among those who do not yet acknowledge it are Dr. and Mrs. Huggins. Writing of their observations of February 1893, they say: "We wish to speak at present with great reserve, as our knowledge of the Nova is very incomplete; but we do not regard the circumstance that the two groups of lines above described fall near the positions of the two principal nebular lines as sufficient to show any connection between the present physical state of the Nova and that of a nebula of the class which gives these lines."

But I may say, at all events, that I have the great authority of the names of Campbell, Copeland, and Gothard, who state that they have certainly observed the spectrum to be that of the nebulæ, and in reply to Dr. Huggins, Prof. Campbell says: "If the spectrum is not conceded to be nebular, I must ask what else we should expect to find in that spectrum, if it were nebular?" The answer to that is, that you would not expect to find anything else because it is all there already. In fact, out of nineteen lines observed or photographed by Prof. Campbell in the spectrum of the Nova, eighteen correspond perfectly with nebular lines. "Therefore the spectrum is nebular, and the fact that the lines have remained broad, or may have remained multiple, does not militate against the theory."

Further, there is even telescopic and photographic evidence of the fact that Nova Aurigæ became a nebula. Dr. Max Wolf's photographs of the Nova and its surroundings in 1893, resulted in the discovery of a number of new diffuse nebulæ in its vicinity, "and there even appeared to be traces of nebulous appendages proceeding from the star itself."

Another new star appeared in the southern constellation Norma in 1893. This was discovered on October 26, on a photograph taken at Arequipa, Peru, on July 10, 1893. Fortunately the photograph was one showing the spectra of stars instead of the simple images of the stars themselves, and the spectrum was seen to be identical with that of Nova Aurigæ. Even more important were the observations of Campbell in February and March 1894, when the star was about 10th magnitude. As the result of his work, he stated that "there can be no doubt that the spectrum of Nova Normæ is nebular."

J. Norman Lockyer.

(*To be continued.*)

THE FLUORESCENCE OF ARGON, AND ITS COMBINATION WITH THE ELEMENTS OF BENZENE.[1]

M. BERTHELOT read the following paper, containing observations by M. Deslandres and himself, before a recent meeting of the Paris Academy of Sciences:—

I have thought it useful to study more closely the conditions of the combination with benzene under the influence of the silent discharge and those of the special fluorescence which accompanies it.

M. Deslandres, whose great competence in spectroscopic questions the Academy is well aware of, has been kind enough to help me in these new determinations, made with higher dispersion, and rigorously determined by photography. It is my duty to thank him here for this long and laborious work.

We must remember that the combination of argon with the elements of benzene, under the influence of the silent discharge, is a slow process; according to the present research, it is accomplished with the help of mercury, which intervenes under the form of a volatile compound. The use of very frequent discharges appears not to modify the general characters of the reaction.

At the beginning, nothing is seen in daylight, and it is only in a dark room that one perceives a feeble violet glow, similar, in its intensity, to that which the discharge develops generally in gaseous systems. At the end of an hour, when in a dark room, a green glimmer is seen, which occupies the middle of the interval between the spirals of the platinum band wound round the discharge tube, the luminous spectrum gives two yellow lines at λ 579 and 577, a green line at λ 546, and a green band at λ 516·5. These different lines will be defined by-and-by.

The photographic spectrum, taken during this time, with an hour's exposure, shows the principal bands of nitrogen, as well as a blue line λ 436, a violet line λ 405, and an ultra-violet line λ 354; these latter being more feeble than the bands of nitrogen.

During the following hours, the green glow constantly increases, the yellow lines and line λ 546 increase, and the band λ 516·5 diminishes. At the end of eight hours, the bands of nitrogen have almost entirely disappeared in the photograph; without doubt it is because the corresponding nitrogen has been absorbed by the benzene.

Seven additional hours of sparking bring the fluorescence to a brilliant emerald colour, visible in broad daylight; the intensity of this phenomenon, as I have already had occasion to say,

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[1] Translated from *Comptes rendus*, June 24, pp. 1386–1390

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not to be compared with the fluorescence developed by the discharge in any known gas. The yellow and green lines can be seen and measured in the spectroscope in full daylight.

The photographs give the following lines wave-lengths, λ λ 579, 577 and 546; 436, 405, 354, 313 and 312 (ultra-violet); one can see two violet lines besides, 420 and 416, scarcely visible, and the lines 385 and 358.

The spectrum observed at the end of fifteen hours was maintained during thirty consecutive hours.

Although advantage has been taken of photography for the registration of these phenomena, care must be taken not to confound such effects, observed in the daytime and under normal pressure, with the glows developed by the discharge in very rarefied gases, such as are generally observed in a spectroscope.

The meaning of these lines is as follows:

The line λ 579 is simply one of the lines visible in daylight, and under normal pressure, which I had described in *Comptes rendus* (t. cxx. p. 800), pointing out that it was probably double. The lines λ λ 580·1 and 577·1 described in the spectrum of rarefied argon, by Mr. Crookes (Jan. 24, 1895), must be compared with them.

Line λ 546 is also described (547) in my preceding note, and answers to a strong line 545·6 attributed to the spectrum of rarefied argon by Mr. Crookes. M. Deslandres has recognised the same lines in the spectrum of rarefied argon, which he had prepared by means of lithium. I have verified, by juxtaposition, the coincidence of the last line of rarefied argon with that of my tube.

I have also announced line 436, found again in the photograph, and very close to 434·5 of rarefied argon (Crookes). The lines 420 and 416 coincide with the very strong lines 420·1—419·8 and 415·96 of rarefied argon (Crookes). The line 405 can be identified with the line 404·4 of Crookes (argon). I have verified the coincidence. Line 385 coincides with Crookes' strong line 385·15 (argon). Line 354, with a group of strong lines at 354·7—353·4 of argon (Crookes). Line 358 with Crookes' group of strong lines 358·7—357·5 (argon).

λ 516·5 is a hydrocarbon band; 313 and 312 are the lines of the vapour of mercury vapour.

None of these lines, as I have already stated, coincide either with the line of helium (587·5) or with the principal line of the aurora borealis (557), although the latter is very near to a strong line of argon (555·7). If the actual fluorescence is not the same as that of the aurora borealis, still its development, and the nearness of the preceding lines, establish a probable relation between this meteor and the existence of argon in the atmosphere.

Here a very important circumstance presents itself. While examining the table of argon lines, given by Mr. Crookes, certain lines were seen to coincide with certain lines of the vapour of mercury. The same coincidence is found in the straight lines visible in daylight, under the normal pressure, in the fluorescence developed during the reaction of benzene on argon. Such are, according to M. Deslandres, the yellow lines 579 and 577; also the very characteristic green line 546, the blue line 436, the violet line 405, the ultra-violet line 354. On the contrary, the lines 420, 416, 385, 358, belong to argon only, the lines 313 and 312 to mercury.

M. Deslandres attributes the common lines to the presence of the vapour of mercury, either in rarefied argon, or in the fluorescent light obtained with benzene under normal pressure.

Nevertheless, as no known gas gives this fluorescence, or these lines, under normal pressure in operating with mercury, it is not possible to explain their production merely by the presence of this vapour alone. Otherwise it would not be understood why they did not show themselves in pure argon, in the presence of mercury under normal pressure, and that they would not produce themselves during the first moments of discharge, either with argon saturated with benzene, or with sulphide of carbon over mercury, or with nitrogen under the same conditions, where it combines with benzene and sulphide of carbon. On the contrary, with argon saturated with benzene, they develop themselves only at the end of several hours, and after the progressive transformation of the benzene into a series of compounds more and more condensed. It is one of these compounds which, immediately it is formed, unites itself both with argon and mercury, associated perhaps by reason of their common character of monatomic molecules. The fluoresence begins when there still exists a notable quantity of liquid benzene in the tubes; it is then accompanied by a diminution of gaseous volume.

This fluorescence continues a very long time, even after there is no apparent benzene; at last the fluorescence ceases to be visible in the daylight, in consequence of the very prolonged action of the discharge, which at last extinguishes the green tint, and brings back this gaseous system to a glow analogous to that of ordinary gases, this happens doubtless in consequence of the destruction of the last traces of benzene (or the products of intermediate condensation), which maintained the equilibrium of the dissociation of the system.

Once the green fluorescence is well established, the compounds which develop it are stable by themselves; even after twelve hours' break, if the apparatus has not been disturbed, it suffices to pass the discharge, to see that the fluorescence re-establishes itself with all its brilliancy in an instant. But it ceases so soon as the electric current is stopped.

But if the gas is separated from the condensed matter, the phenomenon cannot be immediately produced, either on the one or on the other. The gas alone, subjected to the action of the discharge, puts on almost immediately a special violet fluorescence, visible in darkness, and which generally precedes the development of the beautiful green fluorescence. Nevertheless this does not reproduce itself then, which seems to indicate that the condensed matter contains one of the products necessary to the equilibrium. If, on the other hand, new argon is reintroduced into the tube containing the condensed matter (free from visible benzene), the green fluorescence does not reproduce itself; but after some time, near the surface of the mercury, there appears, where the sparking is most intense, a local green tint, which gives the special lines, although not very distinctly. This appearance is doubtless due to the existence (or to the regeneration) of a trace of benzene, more or less modified. In fact, if a few more drops of liquid benzene are added in the tube which contains the condensed matter and the new argon over mercury, half an hour is enough to make the green tint reappear in all its brilliancy. But if there is an excess of benzene, several hours are required for its reappearance.

These various observations, added to the limited character of the absorption of argon, demonstrate the existence of a complex state of equilibrium, in which at the same time argon, mercury, and the elements of benzene, or rather a compound condensed from it, are concerned.

THE REFORM OF OUR WEIGHTS AND MEASURES.

THE Report of the Select Committee appointed to inquire whether any, and what, changes in the present system of weights and measures should be adopted, has been published as a Parliamentary paper.

Evidence from witnesses representing official, commercial, manufacturing, trade, educational, and professional interests was received by the Committee, and numerous corporations, School Boards, and other public bodies sent resolutions in favour of the adoption of the metrical system.

All the witnesses expressed a strong opinion as to the complicated and unsatisfactory condition of the present weights and measures in use, and of the distinct and serious drawback to British commence, especially in the foreign trade, which this system entails, differing as it does from the system (metrical) now adopted by almost every European nation, as well as by far the majority of non-European countries with which this kingdom trades. The evidence also showed that the home trade would be benefited if more simple and uniform standards of weights and measures than those now existing were adopted.

Moreover, strong evidence was brought forward as to the serious loss of time incurred by English school-children in having to learn the complicated system of tables of existing weights and measures, and the urgent need of the adoption of a simpler system. It was stated that no less than one year's school time would be saved if the metrical system were taught in place of that now in use.

Evidence from competent witnesses proved to the satisfaction of the Committee that a compulsory change from an old and complicated system to the metrical had taken place in Germany, Norway and Sweden, Switzerland, Italy, and many other European countries without serious opposition or inconvenience; that this change was carried out in a comparatively short period; and that as soon as the simple character of the new system was understood it was appreciated by all classes of the population,

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